Appendix A
A Discussion of Reserves Appreciation in the California OCS

by Harold E. Syms

Reserves appreciation (reserves growth) is the amount of oil and gas resources in known accumulations that is expected to augment proved reserves as a consequence of the extension of known pools within existing fields, discovery of new pools within existing fields, or the application of improved extraction techniques. A preliminary study of reserves growth in the California Outer Continental Shelf (OCS) was performed in conjunction with this assessment in order to more thoroughly estimate the oil and gas resources of the Pacific OCS Region and to incorporate significant findings regarding reserves growth in the estimation of the Region's undiscovered conventionally recoverable oil and gas resources. A discussion of the data, methodological approaches, and conclusions of this study is presented here.

Data

A total of 38 fields have been discovered in the California OCS; oil and gas were first produced in 1968 and were being produced from 11 fields at the time of this assessment (January 1, 1995) (Sorensen and others, 1995). The Minerals Management Service has developed estimates of proved and unproved oil and gas reserves in discovered fields of the California OCS since 1976 using decline-curve and volumetric analyses. Estimates of proved reserves from 11 producing fields comprise the database used to study reserves growth in the California OCS. A total of approximately 70 reserves estimates have been developed for the 11 fields; the number of estimates for individual fields ranges from 2 to 11.

Approaches

Two methodological approaches were considered for the study of reserves growth in the California OCS. An empirical approach, in which reserves estimates from the producing fields in the California OCS were studied to calculate a reserves growth factor, was followed and is described. An analog-based approach involving the use of a reserves growth factor from other areas was also considered; the rationale for rejecting this approach is also described.

Empirical approach

Volumetric estimates of proved oil and gas reserves for the 11 producing fields in the California OCS were compiled and reserves growth factors were calculated using the methodology of Root and Attanasi (1993). The results of this analysis indicate that there is not a common trend of reserves growth among the 11 fields. Several of the fields show positive growth; other fields show negative or no growth. Therefore, it was determined that a common reserves growth factor could not be calculated for the limited number of fields and that reserves growth for fields in the California OCS could not be estimated using this approach.

Analog approach

An alternative approach, in which empirically derived reserves growth factors for fields in other (analogous) areas may be applied to fields in the California OCS, was also considered. The analogous areas that were considered include onshore California and the Gulf of Mexico OCS.

Onshore California

Reserves growth factors have been calculated for onshore fields in California (Caroline Isaacs, oral commun.). Notable differences in lithology, recovery methods, and other factors in the onshore and OCS areas exist, and these factors have been considered in determining the applicability of reserves growth factors from fields onshore California to fields in the California OCS.

Most of the oil and gas produced from fields onshore California has been extracted from sandstone reservoir rocks. Although most of the oil and gas produced from fields in the California OCS (56 percent on the basis of combined oil-equivalent resources) has been extracted from Neogene sandstone reservoir rocks, the majority of original recoverable reserves in all fields of the California OCS (67 percent on the basis of combined oil-equivalent resources) is in Neogene fractured siliceous rocks of the Monterey Formation (Sorensen and others, 1995). Seven of the 11 producing fields in the California OCS have substantial reserves in the Monterey Formation, as do 21 of the 27 nonproducing fields. The reservoir and production characteristics of Monterey Formation rocks in California OCS fields are significantly different from onshore fields, and reserves growth factors are expected to differ substantially.

An important factor contributing to reserves growth of fields onshore California is enhanced recovery; a significant portion (55 percent) of the oil produced in California in 1994 was produced using secondary and tertiary recovery (including thermal stimulation and water flooding) methods (California Division of Oil, Gas, and Geothermal Resources, 1995). Of this incrementally recovered oil, 77 percent was produced using thermal stimulation, mainly in the southern San Joaquin Valley, where reservoir rocks typically consist of shallow, upper Tertiary sandstones containing heavy (less than 20 °API) oil. Thermal stimulation was tested with limited success in sandstone reservoir rocks in the California State offshore area[1]; it has not been used in the California OCS. The different lithology and greater depths at which Monterey Formation reservoirs exist in the California OCS (generally 5,000 to 8,000 feet below the seafloor) have precluded efforts at thermal stimulation of fractured siliceous reservoirs in the OCS. Although thermal stimulation is not considered to be practical for fields offshore California under current technological and economic conditions, it may be practical for certain Neogene sandstone reservoirs in the California OCS if future economic conditions are more favorable.

Water flooding accounted for 21 percent of the incrementally recovered oil produced in California in 1994 (California Division of Oil, Gas, and Geothermal Resources, 1995); approximately one half of this oil was produced from sandstone reservoir rocks in fields of the onshore and State offshore areas of the Los Angeles basin. Water-flooding methods have also been applied in sandstone reservoirs of fields in the California OCS. Five of the 11 producing fields are undergoing water injection; water injection was initiated concurrently with oil and gas production in 3 of these fields. Although water-flooding methods have increased recovery in sandstone reservoirs, their application to Monterey Formation reservoirs in the California OCS is unknown.

Reserves growth onshore California is also expected to differ from reserves growth in the California OCS due to factors other than lithology and recovery methods. For example, the limited number of drilling slots on offshore platforms may restrict infill drilling and production (i.e., some existing wells must be abandoned before additional wells can be drilled) and may, therefore, reduce calculated reserves growth. Also, premature abandonment of OCS wells due to unfavorable economic conditions may reduce reserves growth. In contrast, the application of advanced drilling techniques (e.g., horizontal and extended-reach drilling) in some fields of the OCS[2] has increased production and is expected to result in increased reserves growth.

Studies of fields in the Gulf of Mexico OCS indicate that their reserves estimates characteristically increase at a slower rate and for a shorter duration than estimates for fields in the adjacent onshore area (Lore, 1995a), and that this is a consequence of more accurate initial reserves estimates for the OCS fields. The increased accuracy of OCS reserves estimates may be attributed to a combination of factors, including the availability of high-quality marine seismic-reflection data, the drilling and analysis of additional exploratory and development wells prior to development decisions, the additional time elapsed after initial field discovery prior to the initial estimate of proved reserves, and the obligation of the assessor to more accurately estimate reserves because of the increased capital requirements of offshore projects. All of these factors apply to fields in the California OCS, suggesting that reserves growth in these fields will be less than fields onshore California.

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[1] A thermal-stimulation test was conducted in the State offshore portion of the Huntington Beach field from 1981 to 1986. The project was conducted in shallow (about 2,000 feet below the seafloor) Pliocene and Miocene sandstone reservoirs with heavy oil ranging from 11 to 14 °API. Due to economic and other constraints, the project was not expanded and the wells have been shut in since 1987.

[2] In the Dos Cuadras field of the Santa Barbara-Ventura basin, an approximate 5-percent increase in recovery was achieved by drilling horizontal and trilateral wells to produce very shallow (less than 1,000 feet below the seafloor) sandstone reservoirs that could not be reached by conventional directional drilling.

Based on these differences in lithology, recovery methods, and other factors in the onshore and OCS areas of California, it was determined that reserves growth factors from fields onshore California are not applicable to fields in the California OCS, and that reserves growth for fields in the California OCS could not be estimated using this approach.

Gulf of Mexico OCS

Reserves growth factors have also been calculated for fields in the Gulf of Mexico OCS (Drew and Lore, 1992; Lore, 1995a; Lore, 1995b). Notable differences in lithology, field size, and wells in fields of the Gulf of Mexico OCS and California OCS exist, and these differences have been considered in determining the applicability of reserves growth factors from fields in the Gulf of Mexico OCS to fields in the California OCS.

The primary oil and gas reservoir rocks in fields of the Gulf of Mexico OCS are shelf sandstones and carbonates (Bacigalupi and others, 1996); no fractured siliceous rocks similar to the Monterey Formation exist. Also, the sizes of individual fields in the Gulf of Mexico OCS are generally smaller than fields in the California OCS; many platforms in the Gulf of Mexico OCS have only one or two wells. These differences contribute to the expectation that reserves growth factors for fields in the Gulf of Mexico OCS and California OCS are much different.

Based on differences in lithology, field size, and wells in fields of the Gulf of Mexico OCS and California OCS, it was determined that reserves growth factors from fields in the Gulf of Mexico OCS are not applicable to fields in the California OCS, and that reserves growth for fields in the California OCS could not be estimated using this approach.

CONCLUSIONS

It was determined that a common reserves growth factor for fields in the California OCS could not be calculated with the existing data. Furthermore, reserves growth factors for fields onshore California and in the Gulf of Mexico OCS are not considered to be applicable to fields in the California OCS. Therefore, reserves growth for fields in the California OCS could not be estimated.

The assessment methods used to develop estimates of undiscovered conventionally recoverable oil and gas resources in petroleum geologic plays of the Pacific OCS Region allow for ample uncertainty in estimating the sizes of individual pools and fields. The amount of reserves growth that may occur in fields of the California OCS is not expected to have a statistically significant impact on the estimates of undiscovered conventionally recoverable resources of the Region.

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